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PENSOFT

New distribution record of Bicolored Trailing Ant, *Monomorium floricola* (Jerdon, 1851) (Hymenoptera, Formicidae) from Ecuador, with information on cohabitation with the social spider *Anelosimus eximius* (Keyserling, 1884)

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Abstract

Invasive ant species are a serious threat to native fauna, especially in highly diverse tropical countries. Therefore, new distribution reports and information on the interactions with other species are essential to understand the potential effects of invasive ants on biodiversity. Here we report for the first time the presence of colonies of *Monomorium floricola* (Jerdon, 1851) in the nest of the Neotropical social spider *Anelosimus eximius* (Keyserling, 1884) in the southern part of the Ecuadorian Amazon. Our report extends the known distributional range of *M. floricola* to the southern Ecuador.

Keywords

Conservation, invasive species, kleptoparasitism, Neotropics

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Introduction

Ants are a cosmopolitan, diverse, and environmentally important group of insects (Hölldobler and Wilson 1990). Some exotic invasive ant species are considered to be the most noxious invaders and pose serious threats to the local fauna. Invading ant species such as *Linepithema humile* (Mayr, 1868), *Pheidole megacephala* (Fabricius, 1793), *Solenopsis invicta* Buren, 1972, *Anoplolepis gracilipes* F. Smith, 1857, and *Wasmannia auropunctata* (Roger, 1893) have been shown to have negative environmental impacts around the world (Sanders et al. 2003; Hartley et al. 2006; Ascunce et al. 2011). This is mainly due to their aggressive behavior, high mobility, and extreme capacity for adaptation to new places (Holway et al. 2002).

Very little is known about invasive ant species in Ecuador, and most of our knowledge derives from reports and research on the Galapagos Islands (Von Aesch and Cherix 2005; Causton et al. 2006; Herrera

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2014; Wauters et al. 2018). Donoso et al. (2014) presented the first account of invasive ant species on mainland Ecuador. Their study reported 16 ant species, including six native and 10 of foreign origin. However, the effects of invasive ants on the Ecuadorian fauna and flora are mostly unknown (Donoso et al. 2014). Research conducted on *L. humile*, *Pachycondyla chinensis* (Emery, 1895) and *W. auropunctata* in other countries has shown that they can have negative effects on the environment by displacing local ant communities, creating dynamic instability, competing for resources, and in some cases causing extinction (Mooney and Cleland 2001; Human and Gordon 2003; Guénard and Dunn 2010; Vonshak et al. 2012). Therefore, it is crucial to integrate new distributional records and reports of invasive ant species interacting with native species into conservation strategies to help control or reduce the effects of these invasive species.

One group of organisms that might face adverse effects of invasive ants are spiders, as they have an antagonistic relationship with ants (Sanders and Platner 2007). This is especially true for social spiders, for which ants are among the most important predators (Henschel 1998; Hoffman and Avilés 2017). Due to their predatory lifestyle, spiders often play a key role in their ecosystems by regulating populations of other organisms as well as recirculating and recycling nutrients (Nyffeler 2000).

Social spiders constitute a small part of the worldwide diversity of the subphylum Chelicerata, with fewer than 30 species having been reported to live in social groups (Kullmann 1972; Burgess 1976; Buskirk 1981). Fourteen species are known to inhabit Ecuador (Avilés et al. 2001), with *Anelosimus eximius* (Keyserling, 1884) (Theridiidae) being the most intensely studied in recent decades (Avilés and Tufiño 1998; Fernandez-Fournier et al. 2018). Colonies of *A. eximius* can be found at lowland to mid-elevations in the Neotropics and can be locally abundant at forest edges—some of those of anthropogenic origin, such as roads, plantations, and deforested areas. Colonies of *A. eximius* inhabit nests that are hemispherical, irregular, or three dimensional depending on the vegetation that serves as their substrate. The nests consist of dense fabric, a woven interior where dry leaves accumulate, and capture threads of many meters that extend from the central nest to the upper vegetation (Avilés et al. 2001). The formation and length of their nests and cooperative hunting behaviours allow *A. eximius* to prey on comparably large insects (Burgess 1976). A colony can consume thousands of prey items in a single day, and thus play a key role as predators in their tropical environment (Burgess 1976). Effects of invasive species on this spider or others might cause cumulative effects on the ecosystem which may need to be evaluated before implementing conservation strategies. Previous studies found that the presence of kleptoparasitic ants reduces the web building activity in social spiders (Drisya-Mohan et al. 2019). But in general, kleptoparasitism effects on social spiders can be influenced by environmental factors such as elevation, host characteristics (nest and colony size), and host hygiene as was demonstrated by Stratus and Avilés (2018) on colonies of *Anelosimus* along an elevation gradient in eastern Ecuador. Here, we report for the presence of an invasive ant species inside the nest of a social spider in the Ecuadorian Amazon region.

Methods

We collected two nests of *Anelosimus eximius* along the Patuca–San Jose de Morona road in Morona Santiago province, Ecuador (Fig. 1), on 3 April 2019. One small nest was found in the town of Palomino along the Palora–Tiwinza road and was 2 m above the ground in a citrus tree in the middle of a park in the town (Fig. 1A). A larger nest was found along the Tiwinza–Puerto Morona road in the Shaime cordillera, on a small hill bordering the road between some bushes and ferns; it was approximately 1 m above the ground (Fig. 1B). The nests with spiders were collected in a cloth bag by cutting the supporting branches of the nest and were transported in a cooler back to the Laboratorio de Entomología at the Museo de Zoología de la Universidad del Azuay (MZUA), Cuenca, Ecuador. In the laboratory, the nests were dissected, and the spiders were relocated into small plastic containers for further research. During this process, several ant nests were found in one of the spider nests. The ants were collected and preserved in 96% ethanol. The preserved specimens are currently deposited in the Entomology Collection of the MZUA.

Ants were initially identified by Dr. David Donoso (Department of Biology, Escuela Politécnica Nacional, Quito, Ecuador) based on photographs. Dr. Donoso is a myrmecologist with extensive experience in taxonomy and ecology of Neotropical ants. His initial identifications were confirmed by examining the external morphology of the ant and comparing it with the description of the species (Wetterer 2010). Spiders were identified by examining morphological features and genitalia using the key by Levi (1956). For morphological measurements and identification, a stereomicroscope Nikon SMZ745T with MSHOT software was used. The preserved ant and spider specimens were photographed with a 5D Mark III Canon SLR camera with a Canon MPE 65 mm lens. The final images are composed of several individual photos combined through a focus stacking technique using Zerene Stacker Software. The final plates were assembled with Photoshop CS6.

Results

In total, three satellite nests of ants were found inside the *Anelosimus eximius* nest collected in Palomino (Figs. 1A, 2). A total of 111 specimens (100 adults and 11 immatures) were found. Queens, workers, and immatures were found inside each ant colony (Fig. 2). The number of individuals of each caste was counted and is summarized in the Table 1. This report increases the

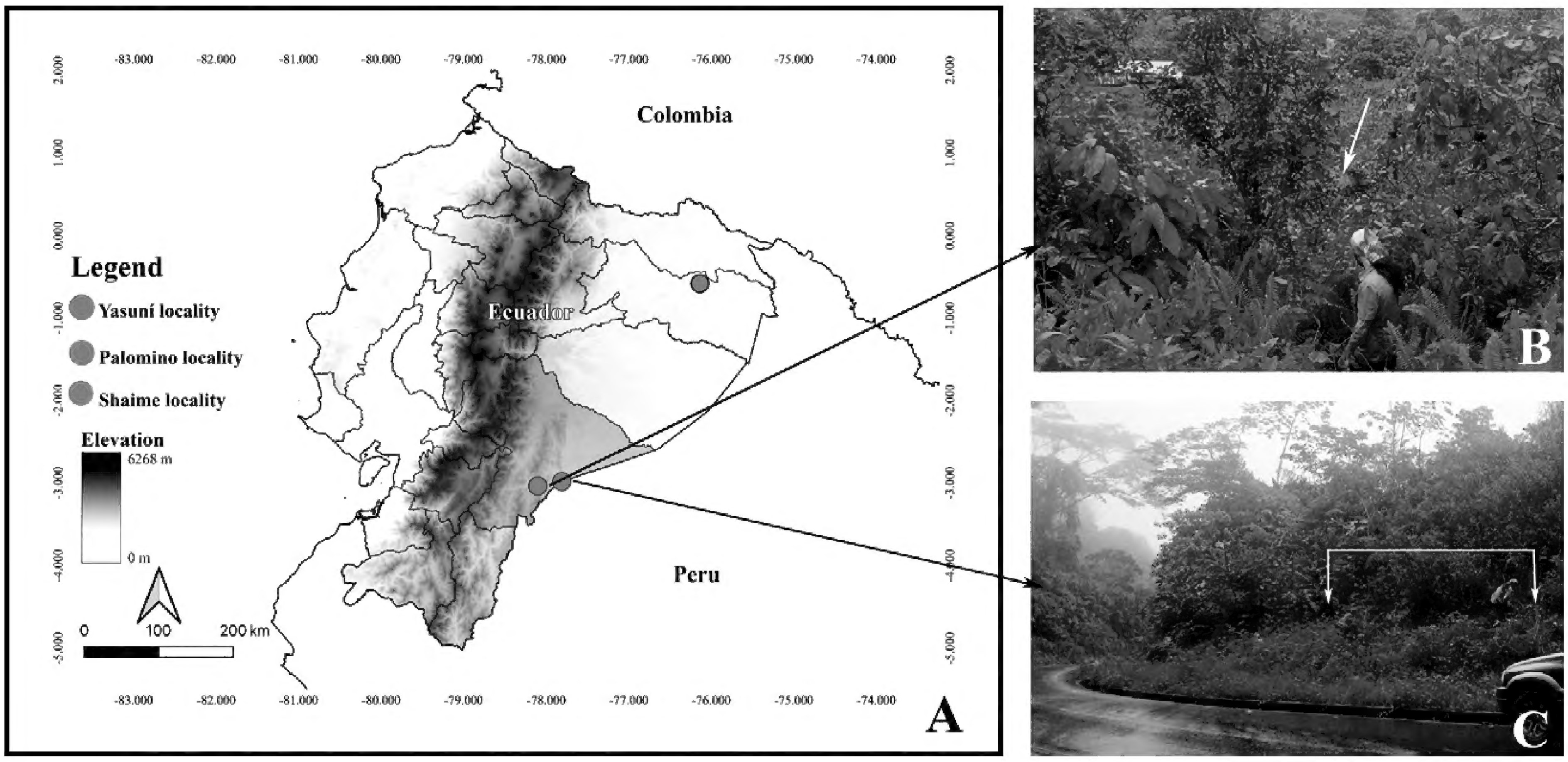

Figure 1. Records of *M. floricola* in mainland Ecuador. **A.** Map of new collecting localities of *A. eximus* in the Morona Santiago province and previous known locality in Yasuní Orellana province. **B.** Spider nest found in Palomino. **C.** Spider nest found near Shaime cordillera. The white arrows indicate the nest locations.

known geographic range of *M. floricola* from the northern to southern Ecuadorian Amazon.

Material examined. ECUADOR – **Morona Santiago** • Palomino; 03.0358°S, 078.1031°W; 388 m alt.; 03.III. 2019; P.S. Padrón leg.; 111 specimens, MZUA-EN47226 to MZUA-EN47337.

Identification. The ants were identified as *M. floricola*, one of the world's most broadly distributed ant species.

Table 1. Colony caste composition and number of individuals for each.

Satellite ant nests	# queens	# workers	# immatures
Palomino 1	6	51	7
Palomino 2	1	18	0
Palomino 3	2	22	4

It is widely spread in tropical regions of both the Old and New World. This species can easily be diagnosed by its distinctive bicolor appearance, the petiole and post petiolus in contrast to the head, with the pale mesosoma and the uniform dark brown gaster (Wetterer 2010). It is almost wholly arboreal, forming large colonies in trees and bushes in habitats of various degrees of disturbance and is a prominent urban species in most tropical countries (Wetterer 2010). However, due to its small size (<1 mm), cryptic colors, slow movement, and arboreal lifestyle it is often overlooked.

Discussion

The introduction of alien species to natural ecosystems is one of the most serious and least studied problems

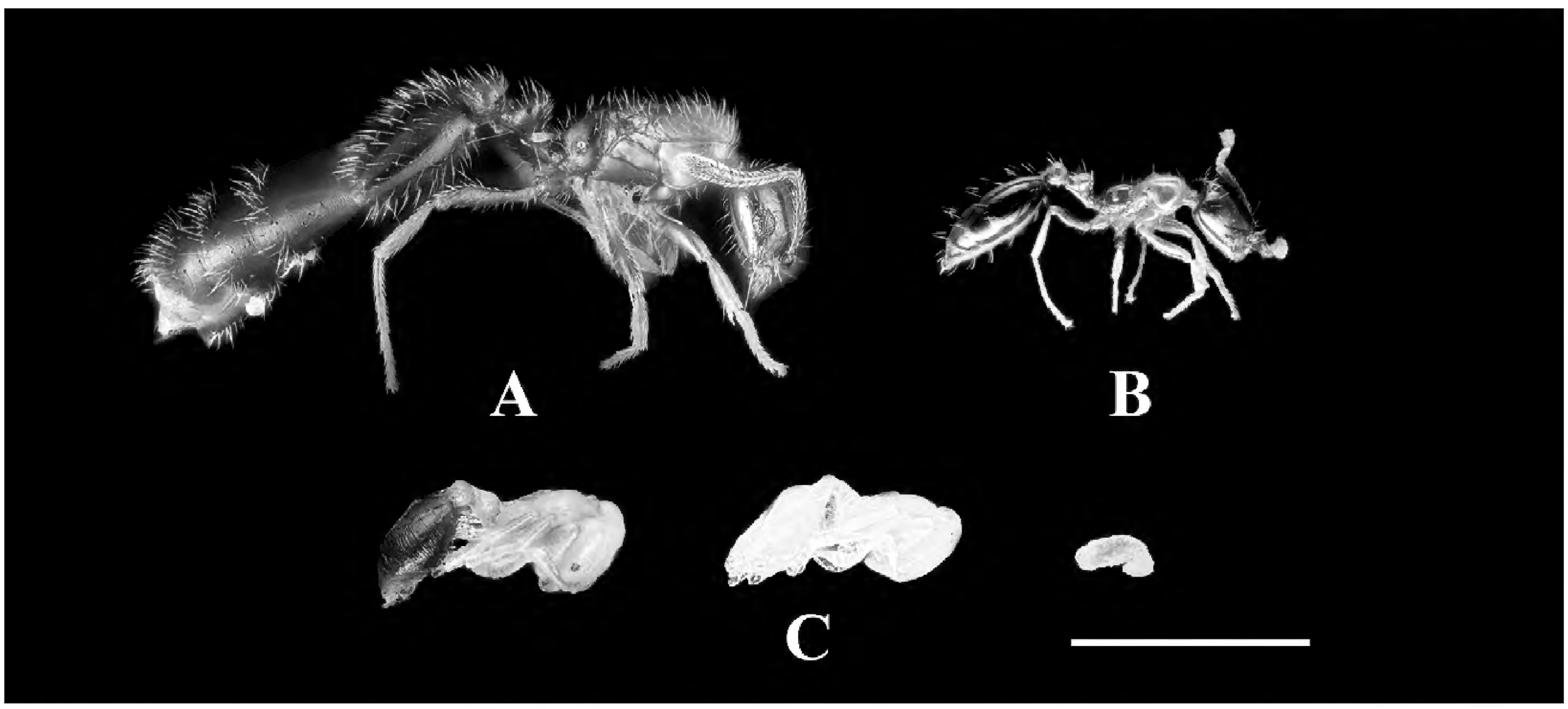

Figure 2. *Monomorium floricola* castes found inside the social spiders' nests. **A.** Queen. **B.** Worker. **C.** Immature. Scale bar = 1 mm.

faced by nature in the context of global change (Early et al. 2016; Russell and Blackburn 2017). Recent reports on invasive invertebrate species show that alien species have become an increasingly common problem in tropical regions (Kumschick et al. 2016), suggesting that the successful conservation of tropical environments and species should consider the presence of new arrivals. Nevertheless, interactions of invasive species with the local environment are rarely investigated and discussed, as they can be difficult to observe. This limited knowledge of the interplay of native and newly established, invasive species is the cause of a lack of understanding over the possible negative effects of alien species on local faunas and floras and may limit the success of conservation efforts.

Here, we report for the first time the co-habitation of the invasive ant *Monomorium floricola* with the Neotropical social spider *Anelosimus eximius*. While spiders living within ant nests have been reported many times in the past (e.g., Cushing 2012; Pekár et al. 2018), to our knowledge this is the first report of ant colonies permanently living within a spider nest in Ecuador; previous South American reports came from Manaus, Brazil (Fowler and Venticinque 1996), which is over 2000 km west of our new record.

Monomorium floricola is one of the world's most broadly distributed ants. The currently known distribution of *M. floricola* suggests that it originated in Asia and spread around the world (Wilson and Taylor 1967; Dlussky 1994; Wetterer 2002; Snelling 2005; Abbott et al. 2006). In Ecuador, this species has been previously reported from the Galapagos islands (Von Aesch and Cherix 2005), and from Yasuni National Park in the northern Ecuadorian Amazon (Donoso et al. 2014). Our new record from Morona Santiago province extends the distribution of this species south by 325 km.

Despite it being a very widespread invasive species, *M. floricola* is rarely considered a serious pest (Wetterer 2010). However, the presence of ant colonies in a nest of a social spider suggests a close interaction with a native species, which may have negative consequences for the host spider. Invasive ants are known to compete with local fauna for resources (Drsya-Mohan et al. 2019). In the present case, competition might manifest in the form of kleptoparasitism, in which the ant steals prey that has been captured and killed by the spider (Cangialosi 1990), and this would result in a reduction of food availability for the spider colony. Social spiders usually capture several prey items that are often larger than themselves and therefore, they need to store the food in their web or nest for later consumption (Nentwig 1985). This food-handling behaviour makes social spiders frequent targets of kleptoparasites (Cangialosi 1990; Drisya-Mohan et al. 2019). We believe that it is likely that this behavior is being exploited by *M. floricola*, which would explain why we found small ant colonies inside the spiders' nest. It is known that kleptoparasites maintain a low density in order to not seriously affect the survival of their host, and therefore allow the coexistence of the species and prevent mutual local extinction (Reding et al. 2016). However, due to kleptoparasitism, limited resources are left for the spiders which may prevent the colony from thriving. Siddiqui et al. (2021) also showed that ants can have negative effects on, especially, native species, altering the dynamics, composition, functions, and structure of natural ecosystems.

There causes of invasion of alien ant species to new areas differ, but most of the recent and important invasions are linked to anthropic activities (Bertelsmeier 2021), which aids in dispersal and initial invasion in new areas. Queens of *M. floricola*, do not have wings and therefore cannot disperse by flying to new areas. Instead, new colonies are formed through local budding, where a fragment of a large colony separates to form a new colony (Wetterer 2010), but the small workers of *M. floricola* move very slowly, which severely limits their dispersal by land (Wetterer 2010). These characteristics make them unable to migrate long distances independently. However, they regularly reach new and distant places through anthropogenic means of dispersal. The southern Amazon region of Ecuador has experienced a significant human population growth in recent years. New human settlements and the growth of already existing towns, as is the case of Palomino town where we found the ant colonies, increases the demand for the transport of materials from elsewhere, and such activities have likely facilitated the spread of *M. floricola* to Palomino. Several characteristics of *M. floricola* promote this mode of dispersal and facilitate infiltration of a social spider's nest: polygynous colonies with multiple fertile queens, a polydomous lifestyle, with workers interacting freely among multiple small nesting sites, and the ability to nest in the smallest of cavities (Frumhoff and Ward 1992; Snelling 2005). Although, *M. floricola* is generally not viewed as a pest, the impacts of this invasive ant species are assumed to be greater than is generally appreciated, not only in disturbed environments, but also in some natural habitats (Wetterer 2010).

Future studies should not only aim to provide a clearer picture of how these and other invasive ant species can disperse and establish in tropical areas, but also to what extent they might indeed affect the local environment. We observed close interaction between *M. floricola* and the social spider *A. eximius*. Based on this knowledge, further research in the lab and in the field should help determine the nature and effects of the interactions between these two species. Such knowledge should allow for better informed decisions when implementing sustainable conservation strategies in tropical regions.

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Authors' Contributions

Funding acquisition: PSP. Investigation: PSP, LO, PA, JF, AJ. Methodology: PSP, JF, AJ. Writing – original draft: PSP, LO, PA, JF, AJ. Writing – review and editing: PSP.

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